I.—*On the Mesozoic Floras of the Rocky Mountain Region of Canada.*

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(Presented May 27, 1885.)

In a paper read before this Society in 1883, and published in the first volume of its Transactions, I noticed the Cretaceous and Tertiary floras of British Columbia and the Northwest Territories, known up to that time, and described the new species which they had afforded. The lowest Cretaceous flora, that of the Queen Charlotte Islands, has a strictly Mesozoic aspect and affords no Dicotyledonous plants. That of the Dunvegan group on Peace River, on the contrary, abounds in Dicotyledons, and may be regarded as a Middle Cretaceous flora of the age of the Niobrara group or Cenomanian, and is warm-temperate or sub-tropical. The assemblage of plants associated with the coal beds of Vancouver is distinctly Upper Cretaceous, and in its generic forms has a very modern aspect and a decidedly warm-temperate character. A still newer flora is that of the Laramie series, which may be regarded as a transition group connecting the Upper Cretaceous with the Eocene, and is still warm-temperate in its aspect, though differing in its specific, and to some extent in its generic forms.

The material at that time in my hands showed nothing from the Rocky Mountain region certainly Lower Cretaceous, and nothing between the Queen Charlotte series and that of Peace River to fill up the great gap separating these very distinct groups of plants, except a small collection from Suskwa River and Willow Creek, containing the species which I named *Dioonites borealis*, *Pinus Suskwaensis* and *Laurus crassinervis*. These I believed to indicate an horizon lower than that of the Dunvegan group of Peace River, but this could not at the time be regarded as certain.

In the past summer considerable collections have been made by Dr. G. M. Dawson, from troughs of Mesozoic rocks included in the older formations of the Rockies, and which show the existence there of a series of fossil plants whose affinities with those of other regions would entitle them to be called Jurasso-Cretaceous. They consist of ferns, cycads and conifers, some of them identical with, or closely allied to, those of the Jurassic of the Amur country in Siberia, and others similarly related to those of the Lower Cretaceous of Greenland, as these floras have been described by Heer. This group, undoubtedly, represents the flora of the Lowest Cretaceous, which has not hitherto been recognized in Western America, and will form a sure basis from which to trace the development of the vegetable kingdom upward to its more modern forms. Unfortunately, a considerable thickness of beds overlying those holding these more ancient plants, has afforded no fossils, and the next beds in ascending order which afford plants contain, in addition to survivors of the older flora, a few new forms belonging to the Dicotyledo-

nous class. Still higher in the series, the strata abound in Dicotyledonous leaves, closely allied to those of the Dakota series of the United States geologists.

It is proposed to name the older series the KOOTANIE SERIES, after a tribe of Indians who hunted in the country in which it occurs. The upper series may be named, after a typical locality, the MILL CREEK SERIES, and the plants occurring between these two horizons may be termed for the present those of the INTERMEDIATE SERIES. There is good reason to believe that the Mill Creek series is somewhat older than that named in my former paper the Dunvegan group of Peace River.

Dr. G. M. Dawson has furnished the following notes as to what is known of the stratigraphy and distribution of these several groups of strata:—

"Where the Rocky Mountains are intersected by the forty-ninth parallel they form a compact range, entirely composed of Palæozoic rocks, from their base at the eastern foothills to the great Kootanie-Columbia valley on the west.[1] About thirty miles further north, however, important masses of Lower Cretaceous or Jurasso-Cretaceous rocks become involved in the flexures of the older series, upon which they rest with more or less angular unconformity. These rocks also hold, at several stages, conglomerates composed of the underlying series which probably stood out in insular masses in many places. The Cretaceous rocks generally appear to occupy synclinals, which are either simple and narrow, or several miles in width, and hold a number of parallel, more or less closely compressed, folds, which in several cases have been observed to be overturned to the east or north-east. Similar sharp parallel folding occurs in the foot-hill country, which forms a belt along the eastern base of the range; and though, owing to the amount of disturbances, it has hitherto been found impossible to work out the structure in detail, it is probable that sections will ultimately be obtained embracing the entire thickness of the Cretaceous formation, together with a portion of the Laramie. In the region of the great plains, north of the forty-ninth parallel, none of the Cretaceous rocks yet known can be assigned to a position lower than that of the Benton group, and to the south and south-east, in the western states and territories, the basal beds of the Cretaceous, wherever exposed, are of the age of the Dakota group. In connection with the folding above described, however, while some beds probably referable to the Dakota period have been recognized by their fossils, there is evidence of the existence of a much earlier stage of the Cretaceous, which it is proposed to designate locally as the Kootanie series. These rocks consist largely of sandstones, interbedded with shales and shaly sandstones, and including occasional beds of conglomerate; and a zone containing coal seams, which are sometimes of considerable thickness, is represented at a number of different localities. While it is evident on stratigraphical grounds that the position of these beds is far down in the thick series of Cretaceous rocks here represented, no fossils have yet been obtained from them save the plants described in this paper, and on these alone their reference to any particular horizon in the Cretaceous must rest.

"The localities from which plants of this stage have already been collected are scattered over a considerable area north of the forty-ninth parallel and south of Bow River, the length of which may be stated as about 140 miles, with an extreme breadth of

[1] There are, it is true, in several places, comparatively small areas of red rocks, believed to be Triassic, but these are conformable with the Devonic-Carboniferous limestone series beneath.

forty miles. Coal Creek and Martin Creek, from which some of the best preserved specimens are derived, are small tributaries of Elk River, on Crow's Nest Pass, west of the watershed range. The point on the north-west branch of the North Fork of Old Man River, which has yielded a small collection, is at an angle of that branch, about two miles above its mouth, east of the watershed range, and between it and the Livingstone range. A few specimens were also obtained on the North Fork, about two miles east of the Livingstone range, in the foot-hill belt. Others were found in the valley of the first small stream crossed by the trail at the entrance to the North Kootanie Pass, and a small collection was also made on Bow River, opposite Canmore Station on the Canadian Pacific Railway. In all these localities the plants were closely associated with seams of coal, which in the last mentioned has become an anthracite. It is further probable, on the evidence of a few fragmentary plants of the same character, that the coals found in the Middle Fork of the Old Man, two miles below the falls, are on or near the same horizon.

"That the series characterized by these plants is a wide-spread and important one, is shown by the fact that one of the species (*Pinus Suskwaensis*) had previously been found on Suskwa River, in northern British Columbia, at a distance of 580 miles north-west of the most northern locality above mentioned. This place is within 150 miles of the Pacific coast, in the centre of a wide area of Cretaceous rocks, chiefly sandstones. In these, at another point, some miles distant, a single mollusc was also found, which appears to be a Thracia, and is regarded by Mr. Whiteaves as very near to, if not specifically identical with, *T. semiplanata*. This species is one of those found in the Cretaceous rocks of the Queen Charlotte Islands about 250 miles distant, which are believed to be of the age of the Gault; and, while it is by no means certain that the horizon from which this fossil was obtained is the same with that yielding *Pinus Suskwaensis*, its presence tends to show that the very thick Cretaceous series of the Skeena and Suskwa region may, in part at least, represent the coal-bearing rocks of the Queen Charlotte Islands.

"Respecting the other places mentioned in this paper, as localities from which plants referable to later stages in the Cretaceous have been collected, the following notes may be given:—

North Branch, North Fork, Old Man River. This place is eight miles from 'The Gap,' where the North Fork leaves the mountains, and within the Livingstone Range.

North-west Branch, North Fork, Old Man River. The fossils so referred are from a point further up the branch than those of the Kootanie series found on the same stream, about fourteen miles from its mouth, and a quarter of a mile up a small stream which enters from the north.

Mill Creek, a tributary of the South Branch of Old Man River in the foot-hills. The specimens are from several points a few hundred yards above the Mill.

South Saskatchewan. Collections from places a few miles below the junction of the Bow and Belly Rivers, near Cairn Hill.

Saskatchewan Coal Mine, near Medicine Hat, on the South Saskatchewan.

Pincher Creek. From cliffs and high banks in the valley, just above the crossing place of the road to the Mill. These beds are in the upper part of the St. Mary subdivision of the Laramie."

It will be observed, that the above stratigraphical notes refer to beds holding fossil plants which range from a very low Cretaceous or Jurasso-Cretaceous horizon upward to

that of the Laramie, which at present is held by Cope and others, on the evidence of its animal fossils, to be Cretaceous, while by Lesquereux its flora is regarded as Eocene. On this question I may remark that as far back as 1875, (when my attention was first called to the flora of this group, by the collections made by Dr. G. M. Dawson in his explorations on the 49th parallel,) I held, on the evidence of the plants, though contrary to what I then believed and still believe to be inaccurate conclusions of certain European palæobotanists, that it should be regarded as a transition group connecting the Cretaceous and the Eocene, and at the same time I stated reasons for believing that the so-called Miocene of Mackenzie River, and of the Fort Union group in the United States, was probably of the same age. I have since that time seen no reason to change my opinion, but on the contrary have found evidence to show that the Laramie flora, or several of its species, may be traced downward into the Cretaceous as far as the beds known as the Pierre group of the geologists of the United States, and those called the Belly River group by the officers of the Geological Survey of Canada. I have been pleased to observe that in Vol. VIII of the Reports of the U. S. Geological Survey of the Territories (1883), Lesquereux now admits that the Laramie is Lower Eocene: and I have no doubt that, as the evidence accumulates, he will come over to the opinion that its flora is really that of the newest Cretaceous; as it has long been held to be in the Canadian territory. It is to be observed, however, that this will carry with it important modifications of opinion as to the Cretaceous and Tertiary floras of the whole northern hemisphere,—points to which I am glad to see that Mr. Starkie Gardner has recently called attention in Great Britain, and to which I shall refer in the sequel of this paper.

I shall now proceed to describe the new plants which have been obtained from the Kootanie and Mill Creek series and the intermediate beds, and to discuss their relations to those elsewhere known in the Mesozoic and Tertiary. With reference to the generic names assigned to these plants, I would desire it to be understood that they are intended to indicate, in the case of leaves more especially, their resemblance to modern genera, but without any dogmatic assertion as to precise affinities. Many dicotyledonous leaves of the Cretaceous might be referred with almost equal probability to several modern genera, and since we know that, in modern times, certain genera present in their different species modifications of foliage more or less imitative of those of other groups, we may well hesitate in affirming that a particular type of leaf was, in Cretaceous times, associated with precisely the same kind of fructification as that which accompanies it in modern times. At the same time it is well known that many kinds of foliage, especially in the case of trees, are markedly characteristic of particular groups; and, since we cannot fairly conclude that the connection of a certain type of leaf with a certain structure of stem and character of fruit is an accident, but must believe that it depends on some law of physiological correlation, we have good reason to rely on this when other evidence is absent. I may state, however, as the result of my experience in many cases, that the conclusions deduced from the leaves have often been confirmed, by the subsequent discovery in association with them of the tissues of their stems, and of the forms of their fruits. It is also to be observed that, plants afford indications of climate and other physical conditions, even more trustworthy than those which can be obtained from animal fossils. From a geological point of view it is to be observed, that while the names assigned to particular leaves may be disputable, the occurrence of the leaves themselves in certain strata over wide areas affords

good palæontological evidence; since these leaves are quite as easily recognized by one familiar with their forms and structures, as any other kinds of fossils.

I shall only premise further that, in referring plants to particular genera and families, I have not been influenced in the least degree by any preconceived ideas as to the probable order of succession of vegetable forms. No one has a right to affirm that, in the case of dicotyledonous plants for example, those families having monœcious or diœcious flowers should have appeared earlier or later than those having bisexual flowers. Long experience in palæontology has convinced me, that the earlier forms of any group of plants or animals may be precisely those which certain framers of hypotheses would least have expected, and that here, as in other departments of the study of nature, we must be prepared to take facts as we find them, in whatever way they may affect our *a priori* opinions.

I.—Kootanie Series.

1. *Filices.*

Dicksonia, Sp.

Pinnate, pinnæ linear, two centimetres long, with rounded sessile pinnules united at their bases. Venation obscure, but apparently of the type of *D. concinna*, Heer, from the Jurassic of Eastern Siberia. The specimens are not quite so distinct as to warrant referring them to Heer's species, yet are so near to it that I hesitate to separate them. They are decidedly of the same type.

Collected by Dr. George M. Dawson at Martin Brook.[1]

Asplenium Martinianum, S. N. (Plate I. Fig. 1.)

Bipinnate, pinnæ long, with somewhat stout petiole. Pinnules contiguous, broad, curved upward, obliquely rounded at their extremities, attached by their whole bases. Midrib delicate, evanescent at distal end, veins very fine, oblique, forking twice. In the specimens studied the pinnæ are 9 centimetres long, and at right angles to the rachis, and the pinnules are 15 millimetres long and 7 broad.

This is a fine luxuriant species, of the general type of the widely distributed Jurassic species, *A. Whitbyanum*, and of its companion, *A. spectabile*.

Collected by G. M. D. at Martin Creek and North Fork, Old Man River.

Asplenium Dicksonianum, *Heer.* (Plate III. Fig. 1.)

Heer, Kreide Flora der Arctischen Zone, 1874, p. 31, Tab. I.

This species, which, according to Heer, is very abundant in the Lower Cretaceous of Greenland, is found at Crow's Nest Pass, near Canmore, and at Coal Brook; and is very plentiful in beds a little higher and belonging to the Intermediate series on the North Fork of Old Man River.

Collected by G. M. D.

Asplenium distans, *Heer.* (Plate III. Fig. 7.)

Heer, Jura Flora Ost-sibiriens. *Pecopteris recentior*, Phillips. *Neuropteris recentior*, Lindley and Hutton.

[1] In subsequent descriptions only the initials, G. M. D., will be given in the case of specimens so collected.

The pinnules are rather larger, more narrow and more pointed upward than in Heer's specimens. It may be described as follows: Bipinnate, or tripinnate, pinnules elongate, free or united only at the base, lanceolate, slightly curved upward, 15 millemetres long and 4 to 5 broad, entire. Midrib slender, giving off veins at an acute angle and which are dichotomous. The species is widely distributed in time and space, and our specimens are probably of one of its varietal forms.

Collected by G. M. D. near Canmore, Rocky Mountains.

2. *Cycadaceæ.*

DIOONITES BOREALIS, *Dawson.* (Plate I. Fig. 2.)

Cretaceous and Tertiary Floras, Transactions of the Royal Society of Canada, Vol. I. Sec. IV. p. 24, Pl. III.

This species was described in the memoir above cited from a specimen collected by Mr. R. G. McConnell, at Willow Creek, in beds known to be Cretaceous, but of uncertain horizon. Additional specimens, collected at Martin Creek by Dr. G. M. Dawson, show that the frond contained twenty or more pairs of pinnules nearly at right angles to the midrib below, but above curving upward to an angle of 30°. The pinnules are 10 to 15 millimetres broad and with 15 to 26 veins.

This frond might be referred to the provisional genus, *Pterophyllum*, but its characters are so much those of *Dioon* that I have no hesitation in giving it the generic name indicating this affinity, and the association of Dioon-like fruits with similar leaves in the Lower Cretaceous of the Queen Charlotte Islands confirms the reference. The genus is elsewhere in the northern temperate regions characteristic of the Wealden and other beds at the base of the Cretaceous, but it extends into the Middle Cretaceous and still exists in Mexico.

Collected by G. M. D.

PODOZAMITES LANCEOLATUS, *Lindley.* (Plate I. Fig. 3.)

Zamia lanceolata, Lindley and Hutton.

Leaves undistinguishable from those of this world-wide species occur in all of the collections from the beds of the Kootanie group throughout its range, and contribute, by their abundance in some layers, to give a Jurassic character to the whole. It is regarded as a Jurassic type, though varieties or sub-species belonging to or allied to it extend into the Urgonian or Lower Cretaceous. This species has been recognised in England, in Sweden, in Siberia, in India, and in China; and Heer, apparently with reason, identifies with it *P. distans* and *P. Eichwaldii*, of Schimper, and *Zamites Haueri*, of Ettingshausen. The specimens from Martin Creek, and from Coal Creek, Crow's Nest Pass, are very good and characteristic, and belong to the ordinary variety. Var. *latifolia* occurs at Martin Creek, and a narrow variety at the Middle Branch of the North Fork of Old Man River. This may be regarded as the most characteristic form in the Kootanie series, and is the more valuable, as nothing resembling it is known to occur in the flora of the Upper Cretaceous.[1]

Collected by G. M. D. at Martin Creek, N. Kootanie Pass, etc.

[1] In his Report of 1883, Lesquereux has noticed several leaflets from the Dakota group referable to this genus.

ZAMITES MONTANA, S. N. (Plate I. Figs. 6, 6A.)

Frond narrow, elongate, pinnate. Midrib strong and as broad as the pinnæ, which are contiguous, parallel-sided, very obtusely truncate, almost rounded at both extremities, thick and coriaceous, with four parallel veins, which are visible only on the under side. Ordinary size of pinnules 7 millimetres long and 2 millimetres broad. This is near to Heer's *Z. arctica* and *Z. brevipennis* from the Lower Cretaceous of Komé, Greenland, but has broader leaves than either, and is altogether larger. It is, perhaps, a variety proper to a more southern latitude.

Collected by G. M. D. at Martin Creek and Kootanie Pass.

ZAMITES ACUTIPENNIS, *Heer*. (Plate I. Fig. 5.)

Heer, Kreide Flora der Arctischen Zone.

This is a fragment of a frond, with pinnules not distinguishable from Heer's species, which is found in the Lower Cretaceous of Ekkorfat, Greenland.

Collected by G. M. D. at Martin Creek.

ZAMITES, Sp. (Plate I. Fig. 4.)

An imperfect leaf, like *Z. borealis* of Heer, as represented in Kreide Flora, Table XV, but too imperfect for certain determination.

Collected by G. M. D. at entrance to Kootanie Pass.

ANOMOZANITES ACUTILOBA? *Heer*. (Plate I. Fig. 7.)

Heer, Jurassic Flora, Ost-sibiriens, Pl. XXIV.

Pinnate, pinnæ broad and short, oblique, rounded at their extremities, contiguous, attached at base, with numerous parallel veins, at right angles to the petiole.

The fragments of this leaf indicate a form very near to *A. Schmidtii* and *A. acutiloba* from the Jurassic of Siberia, more especially to the latter.

Associated with these leaves are racemes of sessile fruits, referable to the genus *Cycadeocarpus*, and which may have belonged to this plant.

Collected by G. M. D. near Canmore.

SPHENOZAMITES, Sp.

A single imperfect leaflet in the shale of Martin Brook, indicates the presence of a cycadaceous plant, probably of this genus. The specimen resembles a leaflet of *S. latifolius*, Brongt, of the Upper Oolite.

Collected by G. M. D.

ANTHOLITHES HORRIDUS, *Dawson*.

Trans. Roy. Soc. Can., Vol. I. Sec. IV. p. 21, Pl. I. Fig. 3

A few fragments of the radiating processes of this remarkable fruit indicate its presence in the beds at Middle Branch, North Fork, Old Man River. Without the perfect specimen from Peace River, described in my former paper, it would have been impossible to recognize these fragments.

Collected by G. M. D.

It will be observed that though some of the above species are represented by specimens too imperfect for detailed description, these are sufficient to establish their distinctness as species, and their reference to the Cycadeæ. We thus have evidence at the same point

of time and in the region extending along the Rocky Mountains, from the 49th to the 51st parallel, of no less than six species of Cycads belonging to at least four generic types; and these types are quite as much Jurassic as Cretaceous in their affinities. Thus we find the Jurassic flora continuing without a break into the Lower Cretaceous, and we shall find that in beds considerably above, we have the beginning of the Dicotyledonous plants of the Tertiary and Modern periods. Thus, in so far as the flora is concerned, the dividing line is in the middle of the Cretaceous; and we may speak of the flora of the Lower Cretaceous as Jurasso-Cretaceous, while that of the Upper members of the series will be Cretaceo-Eocene. Whether the long-enduring and widely-distributed flora, which we have designated by the former name, was strictly contemporary in all parts of its range, may be doubted, though its whole migrations were in this one definite period. It is not impossible that it may have been introduced first into the Arctic, and that in a time of insular land and equable climate, it made its way slowly south. These questions may, however, be better answered in the conclusion of the paper.

3. *Coniferæ.*

SALISBURIA (GINKGO) SIBIRICA, *Heer.* (Plate II. Fig. 1.)

Heer. Jura Flora Ost-sibiriens. 1876, p. 61, Pl. VII.

"Leaf long, petiolate, palmate, frequently lobed, with 8 to 11 lobes, which are oblong and obtuse at their apices. Veins, for the most part 5 to 6, nearly parallel."

The leaf thus described by Heer, represents a group of lobate leaves, very widely distributed in the Jurassic and Wealden formations, and originally referred to the ferns, though Brongniart, from the first, owing to their hard and coriaceous texture, doubted the correctness of this reference. They were at first placed in the genus *Cyclopteris*, and the old *C. digitata*, Lindley, from the English Oolite is very near to the present species. They were afterwards removed to the doubtful genus, *Baiera*, and finally have come to be regarded as taxine leaves allied to those of the Ginkgo tree of Japan, a form represented at the present day by only a single species, limited to the Japanese Islands, but which, in Mesozoic and Tertiary times, possessed several species distributed over the whole of the Northern Hemisphere.

Collected near Martin Brook by G. M. D.

SALISBURIA (GINKGO) LEPIDA, *Heer.* (Plate II. Fig. 2.)

This species, or perhaps only varietal form, is distinguished by Heer, on account of its long and deeply-cleft lobes, attenuated at base and pointed at apex. It is very near to the *Baiera gracilis* of Bunbury, from the Yorkshire Oolite, and leaves closely allied are described by Dunker from the Wealden.

Locality, Martin Brook, and Coal Creek, G. M. D.

SALISBURIA (GINKGO) NANA, S. N. (Plate II. Fig. 3.)

Leaf small, of four narrow lobes, linear obtuse, and arranged in two pairs. Four subparallel veins in each lobe.

This little leaf appears to be distinct from the above species, unless, indeed, it may be a depauperated variety.

Collected by G. M. D. near Coal Creek.

SALISBURIA—Nuts of. (Plate II. Fig. 4.)

Ovate smooth nutlets like those of the modern Ginkgo, but smaller, abound in some of beds of the Kootanie series, and are doubtless the fruit of some of the above species.

BAIERA LONGIFOLIA, *Heer*. (Plate II. Fig. 5.)

Heer, Jura Flora Ost-sibiriens, p. 52, Pl. VIII.

Many fragments of leaves of a Baiera occur at Martin Creek. They indicate a species of the genus, and so far as the material avails, are not far from that above named. *Baiera dichotoma* and *B. cretosa*, which occur in the Lower Cretaceous of Greenland, are also allied forms. Plants of this genus have been placed by Heer among the Taxineæ, near to Salisburia, which, perhaps, represents their probable affinities as well as any other arrangement.

Collected by G. M. D.

PINUS SUSKWAENSIS, *Dawson*. (Plate II. Figs. 6, 6A.)

Dawson, Trans. Roy. Soc. Can., Vol. I. Sec. IV. p. 23, Pl. III. Fig. 37.

This species was described, in my former memoir above cited, from imperfect examples obtained at Suskwa River, the characters given being its long narrow linear leaves, about three inches in length, and borne about eight in a sheath. Many additional specimens both of detached leaves and bundles of leaves occur in the present collections. They shew that the prevalent number of leaves in a sheath was eight, that the leaves were as much as 8 centimetres in length, and that they were rigid, angled and one-nerved. The present species may be compared in age and appearance to *P. Nordenskioldii* from the Jurassic of Siberia, and to *P. Petersoni* from the Lower Cretaceous of Greenland. It is an interesting anticipation of the recent *Pinus strobus*, which it exceeds in the number of leaves in a sheath.

Collected by G. M. D. at Martin Creek, Coal Creek, Crow's Nest Pass.

Along with this species there are detached one-nerved leaves of broader form, which may have belonged to some other species of Pinus, or allied coniferous tree.

SEQUOIA SMITTIANA, *Heer*. (Plate II. Figs. 7, 7A.)

Heer, Kreide-flora der Arctishen Zone, Pls. XVII and XX.

"Branches elongate, leaves an inch long, rigid and coriaceous, linear, smooth, somewhat obtuse but acuminate, tending to a distichous arrangement, slightly narrowed at base, adnate-decurrent, mid-rib strong."

This species abounds in the Lower Cretaceous of Greenland, and is there the representative of *S. Langsdorffii* of the Tertiary, and of the modern *S. sempervirens*: but is a finer and more luxuriant species than either. After studying the specimens in the present collections, I am now convinced that the Sequoia from the Coal measures of Vancouver Island, hitherto referred to *S. Langsdorffii*, really belongs to this more luxuriant and better developed species. A cone probably of this species occurs in the collections from the Middle Fork, North Branch, Old Man River.

Large leafy branches collected by G. M. D. at Coal Creek, Crow's Nest Pass.

GLYPTOSTROBUS GRŒNLANDICUS, *Heer*, loc. cit. (Plate III. Fig. 8.)

Fragments not improbably of this species occur along with *Asplenium Dicksonianum* in

the collections from the North Branch, North Fork, Old Man River. The two species are also associated in the Lower Cretaceous of Greenland.

TAXODIUM CUNEATUM, *Newberry*. (Plate II. Fig. 8.)

Newberry, Later American Floras.

A small specimen referable to this species occurs in the collections from the Kootanie series. The species is described by Newberry from the Cretaceous of the west coast, and occurs in the coal measures of Vancouver Island.

4. *Incertæ Sedis.*

TAONURUS INCERTUS, S. N.

It seems doubtful if the objects referred to the above supposed genus of Algæ, are really organic or only concretionary. They have, however, evidently commended themselves to collectors in the west as probably fossils. The species in the present collection may be described as oval, with one deep furrow, and curved striæ proceeding to the margins. It may be a frond, a concretion, or the cast of a burrow like the Rusichnites of the Lower Silurian.[1]

Collected by G. M. D.

II.—INTERMEDIATE SERIES.

The plants thus indicated are from beds on the Middle Branch of the North Fork of Old Man River, supposed to be separated by a considerable interval of barren strata from the beds of the Kootanie series proper. They have afforded numerous specimens of the fern *Asplenium Dicksonianum*, also roots of Equiseta, with rounded tubercles, and branchlets of conifers which resemble *Glyptostrobus Groenlandicus*, Heer, and *Taxodium cuneatum*, Newberry. But their most marked characteristic is the occurrence of two species of Dicotyledonous leaves, which constitute in this region the earliest ascertained indications of plants of so high organisation.

STERCULIA VETUSTULA, S. N. (Plate III. Fig. 2.)

Leaf small, coriaceous, palmately three-lobed, lobes oblong, pointed, middle lobe one-third larger than lateral lobes; margin entire; a strong mid-rib in each lobe: nerves obsolete. Length about 4 centimetres.

I regard the generic name assigned to this leaf as entirely provisional. It has been given merely on account of its resemblance to leaves so named by previous writers. Such a leaf might have belonged to a plant referable, were its flowers and fruit known, to a very different group from to which Sterculia belongs.

Collected by G. M. D. at North Branch, North Fork, Old Man River.

LAURUS CRASSINERVIS, *Dawson*. (Plate III. Figs. 3, 3A.)

Trans. Roy. Soc. Can., Vol. I. Sec. IV. p. 23.

[1] These are the so-called *Rusophycus* of authors, and have recently been reclaimed by Saporta and connected with Cruziana; but I have elsewhere in my Paper on Rusophycus (Canadian Naturalist), and in that on Footprints of Aquatic Animals (Silliman's Journal), advanced what I consider conclusive reasons to show that both Rusichnites and Cruziana are casts of furrows or trails of crustaceans and annellids.

Several fragments of crushed leaves are so similar to the leaf from Suskwa River, thus named in my former memoir, that I give them provisionally the same name. They resemble *L. Nebrascensis* and *L. Proteæfolia* of Lesquereux; but such leaves, so preserved, cannot with certainty be determined; and might be referred to a willow with perhaps as much probability as to a laurus.

Collected by G. M. D. with former species.

The main points of interest with respect to these leaves are that they represent two species and probably two genera of dicotyledonous trees or shrubs, with leaves of very moderate size and such as might occur in a temperate climate, and illustrating palmate and pinnate modes of venation.

III.—Mill Creek Series.

This is believed to be considerably higher in the Cretaceous than the previously mentioned series, though still within the limits of the Middle Cretaceous, and not improbably older than the Dunvegan group of the Peace River District, described in my former paper. It has important points of agreement with the Patoot series of Greenland, and the Dakota group of the Western United States.

1. *Filices.*

Gleichenia gracilis, *Heer.* (Plate III. Fig. 4.)

Heer, Kreide-flora der Arctischen Zone, p. 98.

"Frond small, slender, dichotomous, bipinnate; pinnæ approximate, lower spreading, upper erect; apex attenuate. Pinnules small, triangular, subfalcate, sori round, 1 or two on bases of pinnules."

The species thus characterized has an extensive range in Greenland.

Collected by G. M. D. and T. C. Weston[1] at Milk Creek.

Gleichenia Kurriana, *Heer.*

Lesquereux, Cretaceous Flora, p. 47.

This species, recognized by Lesquereux in the Dakota group, seems to be represented by mere fragments in Mr. Weston's collections from Mill Creek.

Dicksonia munda, S. N. (Plate III. Figs. 5, 5A.)

Frond pinnate, or bipinnate; barren pinnules with linear pointed arcuate pinnæ, narrowed at base and crenate at edges; less than 1 centimetre long. Fertile pinnules narrow with the marginal sori contiguous.

This is a beautiful and well-characterized fern, but unfortunately always in small fragments.

Asplenium albertum, S. N. (Plate III. Fig. 6.)

Bipinnate; pinnæ in upper part of frond elongate, dentate, in lower part pinnatifid with pointed pinnules, united at the bases and pointing upward. Traces of linear sori on the pinnules, which have few-branching veins.

Collected by T. C. W. at Mill Creek.

[1] T. C. W. in following pages.

2. *Cycadaceæ.*

WILLIAMSONIA RECENTIOR, S. N. (Plate IV. Fig. 1.)

Strobile globular or round-oval, about 3 centimetres in diameter, with numerous narrow curved pointed scales.

This fruit, of which there are several specimens in the collections from Mill Creek, resembles more nearly *Williamsonia Blandfordii*, Fiestmantel, from the Jurassic of India, than anything else I have seen.

3. *Coniferæ.*

The collections from Mill Creek are remarkably deficient in specimens of this order. A number of slender branchlets, imperfectly preserved in coarse stone, might be referred to the species *Glyptostrobus gracillimus* of Lesquereux, which also occurs in the Dunvegan group, Peace River, but which is very doubtfully referable to the genus *Glyptostrobus*. They might with just as much probability be referred to *Taxodium*, and as no fruit was found, it will probably be best to await the collection of additional specimens.

4. *Dicotyledones.*

ALNITES INSIGNIS? *Dawson.*

Trans. Roy. Soc. Can., Vol. I. Sec. IV. p. 28, Pl. VIII.

Specimens, unfortunately very imperfect, in the collections from the North Fork of Old Man River, resemble the above species, which was found at Nanaimo, Vancouver Island, in the Upper Cretaceous. If not the same, they belong to an allied form.

PLATANUS HEERI, *Lesquereux.*

Lesquereux, Cretaceous Flora, p. 70, Pl. IX.

"Leaf rounded, bluntly three-lobed, margin entire or undulate, obliquely wedge-form toward petiole, and extending along it." Principal veins diverging at angles of 40° to 45°.

This is a species of the Dakota group.

Collected by T. C. W. at Mill Creek.

PLATANUS AFFINIS, *Lesq.* (Plate IV. Fig. 2.)

Leaf sub-coriaceous, round-hexagonal in outline, rounded margins narrowing in an angle to the petiole. Margin undulate or distantly dentate, venation pinnate, craspedodrome, central veins few, at a somewhat acute angle (about 35°). Lateral veins distant from margin, giving off curved craspedodrome veinlets to margin.[1]

This well marked species is equally characteristic of the Patoot series in Greenland and of the Dakota in the United States, and is one of the most abundant leaves in the collections of Dr. G. M. Dawson and Mr. Weston from Mill Creek and the Middle Branch, North Fork, Old Man River. It thus forms one of the most interesting links of connection between these floras.

PLATANUS AFFINIS, *var.* AMPLA.

Along with the above are leaves resembling it in general appearance, but differing in the wider angle of the principal veins, and in the comparative narrowness of the band of

[1] Lesquereux's description, with slight verbal changes.

marginal veins. It may be a varietal form merely, or may represent a distinct species, and for the present I may characterize it as var. *ampla*, in the hope that more perfect specimens or intermediate forms may reveal its true nature.

LIQUIDAMBAR INTEGRIFOLIUM, *Lesquereux*.

Lesquereux, Cretaceous Flora, p. 56.

Mr. Weston's collection from Mill Creek contains a well-preserved specimen not distinguishable from the above species, which belongs to the Dakota group.

MACCLINTOCKIA CRETACEA, *Heer*. (Plate IV. Fig. 3.)

Heer, Flora Grœnlands, Patoot, Pl. LX.

Leaf membranous, five-nerved, narrowing to the base. Intermediate veins very delicate.

The specimens of this leaf are unfortunately imperfect, and it seems to have been of more delicate texture than most of the others. It agrees, however, with the Patoot species.

Collected by G. M. D. at Middle Branch, North Fork, Old Man River.

PROTEOIDES DAPHNOGENIOIDES, *Heer*.

Heer, Phyllites du Nebraska, p. 17.

Very numerous specimens represent an ovate lanceolate coriaceous one-nerved leaf, not distinguishable from the above, which was originally described by Heer from the Dakota group of Nebraska. Mixed with these, are other leaves of similar character and texture, having the form of *P. acuta* of Heer, but I think it probable that they may belong to the same species.

Collected by T. C. W. at Mill Creek.

CINNAMOMUM CANADENSE, S. N. (Plate IV. Fig. 7.)

Leaf coriaceous, entire, long ovate, narrowing to the base; three-veined from near the base, midrib stout.

This is near to *C. Sezannense*, Heer, which occurs at Patoot, Greenland, but is broader and with the veins at a wider angle. It is intermediate between the above species and *C. Heeri*, Lesq., from Vancouver Island, and of the Dakota group. All these may possibly be varieties of one species, as also may *C. Mississippiense* of the same author. (See his remarks, Cretaceous Flora, p. 84, and Cretaceous and Tertiary Floras, p. 54.) The reference of these leaves to the genus *Cinnamomum* will admit of doubt, till evidence can be obtained as to their fruit.

LAUROPHYLLUM DEBILE, *Dawson*.

Trans. Roy. Soc. Can., Vol. I. Sec. IV. Pl. II. Fig. 7.

Leaves referable to this species, originally collected in the Dunvegan group, Peace River, appear in the collections from Middle Branch, North Fork, Old Man River. (In the figure above referred to, the midrib is much exaggerated in thickness.)

Collected by G. M. D.

LAURUS CRASSINERVIS, *Dawson*.

This species, already mentioned as occurring in the Kootanie series, seems still to survive in the Mill Creek period.

Collected by G. M. D.

ARALIA, Sp.

Fragments of a large leaf which may be *A. Saportana*, Lesq., but is too imperfect for certain determination.

Collected by G. M. D. at Middle Branch, North Fork, Old Man River.

ARALIA ROTUNDATA, S. N. (Plate IV. Fig. 5.)

Leaf large, 7 centimetres long, with five strongly marked ribs at angles of about 20°. General form broad cuneate or fan-shaped, with five rounded terminal lobes.

Collected by T. C. W. at Mill Creek.

ARALIA WESTONII, S. N. (Plate IV. Fig. 6.)

Leaf five-parted and five-veined, basal angle approaching to 90°. Central lobe lanceolate, much larger than next lobes, and these larger than lateral lobes. Surface shining and coriaceous.

Abundant in Mr. Weston's collections from Mill Creek. The generic name is quite conjectural, as the finer textures of the leaf are not apparent. At first sight, in size and general aspect, the leaves resemble those of *Acer campestre*, but are different in details.

HEDERA OVALIS? *Lesquereux.*

Lesquereux, Cretaceous Flora, p. 91.

Form circular to round oval, venation of hederaceous type, and so much like that of the species above named that I think it may safely be referred to it.

Collected by T. C. W. at Mill Creek.

MAGNOLIA MAGNIFICA. *Dawson.*

Dawson, Trans. Roy. Soc. Can., Vol. I. Sec. IV.

A large leaf in Mr. Weston's collections from Mill Creek is similar in form to the leaf of the Peace River species above named, but the venation is not preserved.

PALIURUS MONTANUS, S. N.

Leaf large, about 8 centimetres long, membranous, oblong or long-ovate, entire, three-ribbed, but middle rib greatly dominant and sending off curved veins toward apex; lateral veins slender, near the margin and curved parallel with it.

This genus is represented by species different from the above in the Dakota group and in Greenland. It seems difficult to distinguish fossil leaves of this type from those of the allied genus *Ceanothus*.

Collected by G. M. D. at Middle Branch, North Fork, Old Man River.

PALIURUS OVALIS, S. N. (Plate IV. Figs. 4 and 8.)

Ordinary leaf five centimetres long, and 2.5 wide, almost perfectly elliptical, but a little more obtuse at apex than at base. Midrib strong, lateral veins very faint, in some specimens obsolete.

These leaves differ little in form from *P. membranaceus*, Lesquereux, from the Dakota group, but are more coriaceous.

Collected by T. C. W. at Mill Creek.

JUGLANDITES CRETACEA, S. N.

Leaf small, oval, crenate or bluntly toothed, membranous, with four pairs of veins, curving in a camptodrome manner. Surface rough, ordinary length 4.5 centimetres.

Collected by G. M. D. at Middle Branch, North Fork, Old Man River.

IV.—Belly River and Laramie Series.

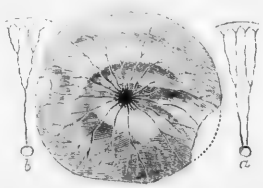
I do not propose in this paper to enter into a detailed description of the species from the Belly River and Laramie beds now in my hands, but merely to state a few facts supplementary to those in former reports and papers, and in anticipation of fuller descriptive lists which I hope to prepare in the future.

Since the publication of my memoir of 1883, I have myself, with the kind aid of Mr. Moses Burpee, then of Calgary, made considerable collections in the railway cuttings at Shaganappi Point, on Bow River, a few miles west of Calgary. Mr. S. R. Byrom, of Drylesden, England, has kindly presented me with an interesting new species from the Belly River series of the South Saskatchewan, and Mr. Weston and Mr. Tyrrell, of the Geological Survey, have made some valuable collections from the Belly River series and the Lower Laramie, which have been placed in my hands by the Director of the Geological Survey. In connection with this, the recent report of Dr. G. M. Dawson has given us, for the first time, a subdivision of the Laramie beds, and the local distribution of the several members.

It is expected that additional specimens will be collected in the summer of 1885, and that it may be possible, next year, to present a somewhat complete account of the Laramie flora and its several subdivisions, and also of the relations of this flora to that of the beds underlying. In the meantime, I shall here give notices of the more interesting new species in the recent collections, and shall notice their stratigraphical distribution in the next section.

Brasenia antiqua, S. N.

Leaves rounded elliptical, entire. Insertion of petiole nearly in the centre, with about eighteen radiating veins forking about half-way to the margin, and a second time near the margin, to join the marginal areolation. Form somewhat less elliptical than in the modern *B. peltata*, and veins more numerous, but otherwise similar.



Brasenia antiqua, Upper Cretaceous, South Saskatchewan River. Leaf natural size. *a*, *b*, Diagrams of Venation, slightly enlarged.

The specimens were obtained in the beds of the Belly River series of the Canadian Survey, near Medicine Hat. These beds are Upper Cretaceous, and hold fossils, some of which resemble those of the Laramie group, others those of the Pierre group. I place their fossil plants with those of the Laramie, because the flora seems to be in the main similar to that of the Lower Laramie. They contain workable beds of lignitic coal; and

the specimens in question were found in nodular clay ironstone, associated with one of the coal beds worked in the Lawson Mine.

A specimen of this interesting fossil, obtained, I believe, from Mr. Lawson, the manager of the mine, was kindly given to me last year by Mr. J. R. Byrom, one of the members of the British Association; and additional specimens, some of them very perfect, were afterwards collected by Mr. T. C. Weston of the Geological Survey.

The modern *Brasenia peltata* is said to occur in British Columbia, Japan, Australia and India, as well as in Eastern America. Not being acquainted with its range of variation in these countries, I cannot certainly affirm that the present specimens are specifically distinct. They may represent merely an ancient varietal form.

In the same bed holding these leaves are other aquatic plants, as *Pistia corrugata*, Lesq., *Lemna scutata*,[1] Dn., *Trapa?* There are also fragments of the great leaves of *Platanus nobilis* and the Populus and Acer described below.

POPULUS LATIDENTATA, S. N.

Base unequally pointed. Margin entire for some distance from base, then with rounded obtuse teeth. Leaf broad above and probably obtuse at apex. The marginal teeth are about the size of those of the modern *P. grandidentata*, but more obtuse, and the leaf resembles in form and size the smaller and narrower leaves of the modern species, to which also it conforms in the character of its venation.

In the same matrix with the above are fragments of leaves of another Populus, of the type of *P. acerifolia*, Newberry.

Collected by T. C. W. in Belly River series, near Medicine Hat.

ACER SASKATCHEWENSE, S. N.

Leaf small, unequally tri-lobed, with the central lobe much longer than the others, and the larger lateral lobe slightly notched, with a rudiment of an additional lobe. Length about 4 centimetres. Width much less than length.

This may be a terminal leaflet of a Negundo, but there were no indications of lateral leaves connected with the specimens, and it resembles very nearly the young leaves of *Acer dasycarpum*.

Collected by T. C. W. in Belly River series, near Medicine Hat.

TRAPA BOREALIS, *Heer*.

This species was recognized by me in 1878, in the collections of Dr. G. M. Dawson from the vicinity of the 49th parallel, in beds probably belonging to the Lower Laramie. Fruits only were found. More recently Lesquereux has found in beds, probably of Laramie age, leaves which he attributes to this genus, and which may possibly belong to the present species. In Mr. Tyrrell's collections from Red Deer River, are fruits similar to those previously described, and also leaves similar to those described by Lesquereux (*Trapa microphylla*). The leaf may be described as ovate-flabellate in form, rounded at base, straight at the diverging sides, and at the end with very shallow rounded sinuses, separating short teeth, which in some specimens are nearly obsolete.

[1] The nature and affinities of this curious plant I shall hope to discuss, with the aid of the new specimens, in a future paper.

Collected by R. B. Tyrrell in the Lower Laramie, at the Red Deer and Rosebud Rivers. This plant is associated at several localities with Pistia and Lemna, and in this respect the beds holding it conform in their flora to the Belly River series on the South Saskatchewan. The same remark applies to the beds at Pincher Creek, Berry Creek, etc., from which places small collections have been obtained.

ABIETITES TYRRELLII, S. N.

Branches stout, with broad and thick leaves, spirally disposed, showing no ribs, and slightly narrowing and decurrent on prominent leaf-bases.

Fine casts of this plant occur in hard clay ironstone at Berry Creek. Collected by R. B. Tyrrell.

SALISBURIA.

Seeds or nutlets referable to this genus were observed in the collections from several places in the Lower Laramie.

The above are all from the Belly River series or the Lower Laramie, in which also occur abundant remains of a Sequoia which I have referred to *S. Reichenbachii*. The remaining species are from the Upper Laramie or Porcupine Hill series.

PLATANUS NOBILIS, *Newberry*.

Newberry, Later Extinct Floras of America.

Large numbers of these fine leaves occur in the Upper Laramie sandstone near Calgary. They show that the peculiarities of venation referred to by Lesquereux in his notice of this species, are only varietal. The leaves from Calgary exhibit the auricles or supplementary leaflets first described by me in the specimens collected by Dr. Selwyn at Souris (Geol. Survey of Canada, 1879.)

PLATANUS RAYNOLDSII, *Newberry*.

Newberry, *loc. cit.*

This species is also abundant and mixed with the former, at Shaganappi Point, near Calgary. Its leaves present many differences in size and form, but these pass into one another.

POPULUS.

In the same beds with the above, are leaves of several species of Poplar, which I refer provisionally to *P. acerifolia*, *P. genetrix* and *P. cordifolia*, of Newberry.

SASSAFRAS (ARALIOPSIS) BURPEANA, S. N.

Leaf three-lobed, long petioled, lateral ribs at angle of about 30° to middle rib. Secondary veins very strong, the inner ones joining at an obtuse angle in the palm of the leaf. Leaf probably trifid at apex, and somewhat rounded and auriculate at base.

Collected by Mr. Burpee near Calgary, Upper Laramie sandstone.

VIBURNUM OXYCOCCOIDES, S. N.

Leaf large, tri-lobed, central lobe long and acute, lateral lobes rounded at margin. Auriculate with two small rounded leaflets at base. Venation almost precisely as in the

modern *Viburnum opulus*, and the leaf is scarcely distinguishable from leaves of that species taken from young and vigorous shoots, except in the auricles at the base.

Collected by G. M. D. at Shaganappi Point, near Calgary.

VIBURNUM CALGARIANUM, S. N.

Leaf simple, nearly round, obtusely toothed at margin. Venation as in *V. rotundifolium*, Lesquereux, except that the ultimate venation is much coarser. The marginal teeth are also much more rounded, being merely waves of the edge.

This leaf is very near in general appearance to that described in my former memoir as *Alnites insignis*, from the Cretaceous of Vancouver Island. I believe, however, it is quite distinct.

Collected by G. M. D. at Shaganappi Point, near Calgary, Upper Laramie.

In the same beds with the above species are oval drupelets of the structure of those of Viburnum, and which may have belonged to the same plants from which the leaves were derived.

SALISBURIA, Sp.

Fragments of a flabellate leaf, similar in form and size to that of the modern ginkgo, and also nutlets, occur in the sandstones of Shaganappi Point.

V.—GEOLOGICAL RELATIONS OF THE FLORAS.

In my memoir in the first volume of the Transactions of this Society, I have given a table of the Cretaceous formations of the western Northwest Territories of Canada, prepared by Dr. G. M. Dawson, and have fully stated the geological position of the plants at that time described. The new facts above detailed now require us to intercalate in our table three distinct plant-horizons not previously recognized in the western territories of Canada. One of these, the Kootanie series, should probably be placed at the base of the table as a representative of the Urgonian or Neocomian, or, at the very least, should be held as not newer than the Shasta group of the United States Geologists, and the Lower Sandstones and Shales of the Queen Charlotte Islands. It would seem to correspond in the character of its fossil plants with the oldest Cretaceous floras recognized in Europe and Asia, and with that of the Komé formation in Greenland, as described by Heer. No similar flora seems yet to have been distinctly recognized in the United States, except, perhaps, that of the beds in Maryland, holding cycads, and which were referred many years ago by Tyson to the Wealden.

The second of these plant-horizons, separated according to Dr. G. M. Dawson, by a considerable thickness of strata, is that which he has called the Mill Creek series, and which corresponds very closely with that of the Dakota group, as described by Lesquereux, and that of the Atané and Patoot formations in Greenland, as described by Heer. This fills a gap, indicated only conjecturally in the table of 1883. Along with the plants from the Dunvegan group of Peace River, described in 1883, it would seem to represent the flora of the Cenomanian and Turonian divisions of the Cretaceous in Europe.

Above this we have also to intercalate a third sub-flora, that of the Belly River series at the base of the Fort Pierre group. This, though separated from the Laramie proper by

the marine beds of the Pierre and Fox Hill groups, more than 1,700 feet in thickness, introduces the Laramie or Danian flora, which continues to the top of the Cretaceous, and probably into the Eocene, and includes several species still surviving on the American continent, or represented by forms so close that they may be varietal merely.

Lastly: the subdivision of the Laramie group, in the last report of Dr. G. M. Dawson, into the three members known respectively as the Lower or St. Mary River series, the Middle or Willow Creek series, and the Upper or Porcupine Hill series, in connection with the fact that the fossil plants occur chiefly in the lower and upper members, enables us now to divide the Laramie flora proper into two sub-floras,—an older, closely allied to that of the Belly River series below; and a newer, identical with that of Souris River, described as Laramie in Dr. G. M. Dawson's Report on the 49th Parallel, 1876, and in the Report of the Geological Survey of Canada for 1879, and which appears to agree with that known in the United States as the Fort Union group, and in part at least with the so-called Miocene of Heer from Greenland.

From the animal fossils and the character of the flora, it would seem probable that the rich flora of the Cretaceous coal fields of Vancouver Island is nearly synchronous with that of the coal-bearing Belly River series of the western plains.

It will thus be seen that the explorations already made in Canadian territory have revealed a very complete series of Cretaceous plants, admitting, no doubt, of large additions to the number of species by future discoveries, and also of the establishment of connecting links between the different members, but giving a satisfactory basis for the knowledge of the succession of plants and for the determination of the ages of formations by their vegetable fossils.

In connection with the subjoined table it should be understood that Tertiary floras, probably Miocene in age, are known in the interior of British Columbia, though they have not yet been recognized in the territories east of the Rocky Mountains.

Before leaving this part of the subject, I would deprecate the remark which I see occasionally made, that fossil plants are of little value in determining geological horizons in the Cretaceous and Tertiary. I admit that in these periods some allowance must be made for local differences of station, and also that there is a generic sameness in the flora of the Northern Hemisphere, from the Cenomanian to the modern, yet these local differences and general similarity are not of a nature to invalidate inferences as to age. No doubt so long as palæobotanists seemed obliged, in deference to authority, and to the results of investigations limited to a few European localities, to group together, without distinction, all the floras of the later Cretaceous and earlier Tertiary, irrespective of stratigraphical considerations, the subject lost its geological importance. But when a good series has been obtained in any one region of some extent, the case becomes different. Though there is still much imperfection in our knowledge of the Cretaceous and Tertiary floras of Canada, I think the work already done is sufficient to enable any competent observer to distinguish by their fossil plants the Lower, Middle and Upper Cretaceous, and the latter from the Tertiary; and, with the aid of the work already done by Lesquereux and Newberry in the United States, to refer approximately to its true geological position any group of plants from beds of unknown age in the west.

The successive series may be tabulated as follows, with references for details to the fuller table in my memoir of 1883:—

SUCCESSIVE FLORAS AND SUB-FLORAS OF THE CRETACEOUS IN CANADA.

(In Descending Order.)

Periods.	Floras and Sub-floras.	References.
Transition Eocene to Cretaceous.	Upper Laramie or Porcupine Hill Series.....	Platanus beds of Souris River and Calgary. Report Geol. Survey of Canada for 1879, and present memoir.
Upper Cretaceous (Danian and Senonian.)	Middle Laramie or Willow Creek Series.	
	Lower Laramie or St. Mary River Series.....	Lemna and Pistia beds of bad lands of 49th Parallel, Red Deer River etc., with Lignites. Report 49th Parallel and this memoir.
	Fox Hill Series	Marine.
	Fort Pierre Series	Marine.
	Belly River Series. (See note).....	Sequoia and Brasenia beds of S. Saskatchewan, Belly River, etc., with Lignites. This memoir.
	Coal Measures of Nanaimo, B.C., probably here.	Memoir of 1883. Many Dicotyledons, Palms, etc.
Middle Cretaceous (Turonian and Cenomanian.)	Dunvegan Series of Peace River. (See note)...	Memoir of 1883. Many Dicotyledons, Cycads, etc.
	Mill Creek Series of Rocky Mountains.....	Dicotyledonous leaves, similar to Dakota Group of the U. S. This memoir.
Lower Cretaceous (Neocomian, &c.)	Suskwa River and Queen Charlotte Island Series.	Cycads, Pines, a few Dicotyledons. Report Geol. Survey. This memoir.
	Intermediate Series of Rocky Mountains.....	
	Kootanie Series of Rocky Mountains.....	Cycads, Pines and Ferns. This memoir.

Note.—Though the flora of the Belly River series very closely resembles that of the Lower Laramie, showing that similar plants existed throughout the Senonian and Danian periods in North America, yet it is to be anticipated that specific differences will develop themselves in the progress of discovery. In the mean time it scarcely seems possible to distinguish by fossil plants alone the Lower Laramie beds from those of Belly River, and if these are really separated by 1,700 feet of marine strata, as is now believed on stratigraphical grounds the flora must have been remarkably persistent. The Dunvegan series of Peace River probably corresponds in time with the marine Niobrara and Benton groups farther south and the Mill Creek with the Dakota group.

VI.—Physical Conditions and Climate indicated by the Cretaceous Floras.

In the Jurassic and earliest Cretaceous periods the prevalence, over the whole of the Northern Hemisphere and for a long time, of a monotonous assemblage of Gymnospermous and Acrogenous plants, implies an uniform and mild climate and facility for intercommunication in the north. Toward the end of the Jurassic and beginning of the Cretaceous, the land of the Northern Hemisphere was assuming greater dimensions, and the climate probably becoming a little less uniform. Before the close of the Lower Cretaceous periods the dicotyledonous flora seems to have been introduced, under geographical conditions which permitted a warm-temperate climate to extend as far north as Greenland.

In the Cenomanian, we find the Northern Hemisphere tenanted with dicotyledonous trees closely allied to those of modern times, though still indicating a climate much warmer than that which at present prevails. In this age, extensive but gradual submergence of land is indicated by the prevalence of chalk and marine limestones over the surface of

both continents; but a circumpolar belt of land seems to have been maintained, protecting the Atlantic and Pacific basins from floating ice, and permitting a temperate flora of great richness to prevail far to the north, and especially along the southern margins and extensions of the circumpolar land. These seem to have been the physical conditions which terminated the existence of the old Mesozoic Flora and introduced that of the Middle Cretaceous.

As time advanced, the quantity of land gradually increased, and the extension of new plains along the older ridges of land was coincident with the deposition of the great Laramie series, and with the origination of its peculiar flora, which indicates a mild climate and considerable variety of station in mountain, plain and swamp, as well as in great sheets of shallow and weedy fresh water.

In the Eocene and Miocene periods the continent gradually assumed its present form, and the vegetation became still more modern in aspect. In that period of the Eocene, however, in which the great nummulitic limestones were deposited, a submergence of land occurred on the Eastern continent which must have assimilated its physical conditions to those of the Middle Cretaceous. This great change, affecting materially the flora of Europe, was not equally great in America, which also by the north and south extension of its mountain chains permitted movements of migration not possible in the Old World. From the Eocene downward, the remains of land animals and plants are found only in lake basins occupying the existing depressions of the land, though more extensive than those now remaining. It must also be borne in mind, that the great foldings and fractures of the crust of the earth which occurred at the close of the Eocene, and to which the final elevation of such ranges as the Alps and the Rocky Mountains belongs, permanently modified and moulded the forms of the continents.

These statements raise, however, questions as to the precise equivalence in time of similar floras found in different latitudes. However equable the climate, there must have been some appreciable difference in proceeding from north to south. If, therefore, as seems in every way probable, the new species of plants originated on the Arctic land and spread themselves southward, this latter process would occur most naturally in times of gradual refrigeration or of the access of a more extreme climate, that is in times of the elevation of land in the temperate latitudes, or conversely, of local depression of land in the Arctic, leading to invasions of northern ice. Hence the times of the prevalence of particular types of plants in the far north would precede those of their extension to the south, and a flora found fossil in Greenland might be supposed to be somewhat older than a similar flora when found farther south. It would seem, however, that the time required for the extension of a new flora to its extreme geographical limit, is so small in comparison with the duration of an entire geological period, that practically, this difference is of little moment, or at least does not amount to antedating the Arctic flora of a particular type by a whole period, but only by a fraction of such period.

It does not appear that, during the whole of the Cretaceous and Eocene periods, there is any evidence of such refrigeration as seriously to interfere with the flora, but perhaps the times of most considerable warmth are those of the Dunvegan group in the Middle Cretaceous and those of the later Laramie and oldest Eocene.

It would appear, that no cause for the mild temperature of the Cretaceous needs to be invoked, other than those mutations of land and water which the geological deposits them-

selves indicate. A condition for example of the Atlantic basin in which the high land of Greenland should be reduced in elevation and at the same time the northern inlets of the Atlantic closed against the invasion of Arctic ice, would at once restore climatic conditions allowing of the growth of a temperate flora in Greenland. As Dr. Brown has shown,[1] and as I have elsewhere argued, the absence of light in the Arctic winter is no disadvantage, since, during the winter, the growth of deciduous trees is in any case suspended, while the constant continuance of light in the summer is, on the contrary, a very great stimulus and advantage.

It is a remarkable phenomenon in the history of genera of plants in the later Mesozoic and Tertiary, that the older genera appear at once in a great number of specific types, which become reduced as well as limited in range down to the modern. This is no doubt connected with the greater differentiation of local conditions in the modern; but it indicates also a law of rapid multiplication of species in the early life of genera. The distribution of the species of *Salisburia*, *Sequoia*, *Platanus*, *Sassafras*, *Liriodendron*, *Magnolia*, and many other genera, affords remarkable proofs of this.

Gray, Saporta, Heer, Newberry, Lesquereux and Starkie Gardner, have all ably discussed these points; but the continual increase of our knowledge of the several floras, and the removal of error as to the dates of their appearance must greatly conduce to clearer and more definite ideas. In particular, the prevailing opinion that the Miocene was the period of the greatest extension of warmth and of a temperate flora into the Arctic, must be abandoned in favour of the later Cretaceous and Eocene; and if I mistake not, this will be found to accord better with the evidence of general geology and of animal fossils.

Note.—While this memoir was passing through the press, the Report of Mr. Whiteaves, F. G. S., Palæontologist to the Canadian Survey, on the invertebrate fossils of the Laramie and Cretaceous of the Bow and Belly River districts appeared. (Contributions to Canadian Palæontology, Vol. i. Part 1, 89 pages and eleven plates). This valuable Report constitutes an independent testimony, based on animal fossils, to the age of the beds in question, and accords in the main very closely with the conclusions above derived from fossil plants. Unfortunately, however, no animal remains have yet been found in the Kootanie series, and the only fossil recorded from the Mill Creek beds is a species of *Inoceramus*, characteristic in the United States of the Niobrara and Benton groups, a position a little higher than that deduced from the plants.

[1] Florula Discoana.